JP-A-2000-260079 M021227
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2000-260079
Public disclosure 2000-260079, September 22, 2000
Patent application 2000-292, January 5, 2000
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54) [Title of the invention]

Method of recording of optomagnetic recording medium and recording device.

57) [Summary]

[Problem]

A method of recording and a recording device wherein a recording mark with the possibility of stable transfer of continuous recording information to a playback layer, can be formed in a recording layer, are offered.

[Means of solution]

One of binary information of 1 bit is allotted to magnetic section pattern 223 that is constituted by a combination of recording magnetic section 221 and magnetic section 222 that has a magnetization with the direction that is opposite to that of the said recording magnetic section 221, and the other binary information of 1 bit is allotted to magnetic section pattern 224 that is constituted by 2 magnetic sections that have a magnetization with the same direction as above mentioned magnetic section 222. Hereby, recording information 225 that continues during 2 or more bits, is formed in the recording layer as a series of magnetic section patterns with a combination of a recording magnetic section and a magnetic section that has a magnetization in the direction that is opposite to that of the said recording magnetic section, as one unit of recording information. From such a magnetic section pattern, a homogeneous leaking magnetic field is obtained, irrespective of the position, and information, even if it is continuous recording information, can be stably transferred to the playback layer.

[What is claimed]

[Claim 1]

A recording method with the characteristic that in the method of recording of optomagnetic recording media wherein information is recorded by irradiating an optomagnetic recording medium with recording light under application of a magnetic field in the recording direction,

1 bit of information is allotted to a combination of a magnetic section that has a magnetization in the recording direction and a magnetic section that has a magnetization in the direction that is opposite to the recording direction, or to a combination of 2 magnetic sections that have a magnetization in the direction that is opposite to the recording direction,

and that in the case that 1 bit of information that consists of a combination of a magnetic section that has a magnetization in the above mentioned recording direction and a magnetic section that has a magnetization in the direction that is opposite to the recording direction, is recorded, continuing for 2 bits or more, the size of the recording magnetic sections is adjusted in such a way that the magnetic section that has a magnetization in the recording direction that is contained in the first bit of information, is shorter that the magnetic section that has a magnetization in the recording direction that is contained in the second and higher order bits of information.

[Claim 2]

The method of recording that has been described in claim 1, with the characteristic that when the length of the magnetic domain that has a magnetization in the above mentioned recording direction is L1, and the length of the magnetic section that has a magnetization in the direction that is opposite to the recording direction, is L2, L1/L2 is in the range of 0.1-0.9.

[Claim 3]

The recording method that has been described in claims 1 or 2, with the characteristic that the size of the above mentioned recording magnetic section that has a magnetization in the recording direction, is in the range of 0.01 μm to 0.36 μm.

[Claim 4]

A recording method with the characteristic that in the method of recording of optomagnetic recording media wherein information is recorded by irradiating the recording layer of an optomagnetic recording medium with recording light under application of a magnetic field in the recording direction,

at least either the recording light or the recording magnetic field are modulated, so that the domain of the recording layer that corresponds with one of binary informations of 1 bit is constituted by a magnetic section that has a magnetization in the recording direction, and a magnetic section that has a magnetization in the direction that is opposite to the recording direction,

and the domain of the recording layer that corresponds with the other binary information of 1 bit is constituted by 2 magnetic sections that have a magnetization in the direction that is opposite to the above mentioned recording direction,

and that when the length of the magnetic domain that has a magnetization in the above mentioned recording direction is L1, and the length of the magnetic section that has a magnetization in the direction that is opposite to the recording direction, is L2, L1/L2 is in the range of 0.1-0.9.

[Claim 5]

The recording method that has been described in claim 4, with the characteristic that the size of the above mentioned recording magnetic section that has a magnetization in the recording direction, is in the range of 0.01 μm to 0.36 μm.

[Claim 6]

The recording method that has been described in claims 4 or 5, with the characteristic that in the case that one of binary informations of 1 bit that consists of ~~a combination of~~ a magnetic section that has a magnetization in the above mentioned recording direction and a magnetic section that has a magnetization that is opposite to the recording direction, is recorded, continuing for 2 bits or more, the size of the magnetic sections is adjusted in such a way that the magnetic section that has a magnetization in the recording direction, that is contained in the first bit of information, is shorter than the magnetic sec-

tion that has a magnetization in the recording direction that is contained in the second and higher order bits of information.

[Claim 7]

A recording method with the characteristic that in the recording method wherein information is recorded by formation of magnetic sections with different directions of magnetization in the recording layer of an optomagnetic recording medium,

one information of information that consists of 2 values is allotted to a sequence of magnetic sections that consists of 2 magnetic sections with different directions of magnetization,

the other information of information that consists of 2 values is allotted to a sequence of magnetic sections that consists of 2 magnetic sections that have the same direction of magnetization,

and the information is recorded in such a way that the ratio of the length of the other magnetic section to the one magnetic section among the above mentioned 2 magnetic sections with different directions of magnetization, is in the range of 0.1-0.9.

[Claim 8]

A recording method with the characteristic that in the case that information that continues for 2 bits or more, is recorded with the use of the above mentioned sequence of magnetic sections that consists of 2 magnetic sections with different directions of magnetization, the size of the recording magnetic sections is adjusted in such a way that the recording magnetic section that corresponds with the first bit of information is shorter than the recording magnetic section that corresponds with the second and higher order bits of recording information.

[Claim 9]

A recording method with the characteristic that in the method of recording of an optomagnetic recording medium wherein information is recorded in a recording layer by irradiation of an optomagnetic recording medium that has been equipped with a recording layer, by recording light under application of a magnetic field in the recording direction,

information is recorded in such a way that in the case of recording of recording information that continues for 2 bits or

more, recording information of at least 1 bit is constituted by a magnetic section that has a magnetization in the recording direction and a magnetic section that has a magnetization in the direction that is opposite to the recording direction.

[Claim 10]

The recording method that has been described in claim 9, with the characteristic that when the length of the magnetic section that has a magnetization in the above mentioned recording direction is L1, and the length of the magnetic section that has a magnetization in the direction that is opposite to the recording direction, is L2, L1/L2 is in the range of 0.1-0.9.

[Claim 11]

A recording method with the characteristic that in the method of recording of an optomagnetic recording medium wherein information is recorded in a recording layer by irradiation of an optomagnetic recording medium that has been equipped with a recording layer by recording light under application of a magnetic field in the recording direction,

in the recording of recording information that continues for 2 bits or more, at least either the above mentioned recording magnetic field or recording light are modulated, so that a magnetic section that has a magnetization in the direction that is opposite to the recording direction, is formed inside the recording domain of the recording layer that corresponds with 1 bit of recording information.

[Claim 12]

The recording method that has been described in claim 11, with the characteristic that the size of the recording magnetic section that has a magnetization in the recording direction inside the recording domain that corresponds with 1 bit of recording information, is in the range of 0.01 μm to 0.36 μm.

[Claim 13]

The recording method that has been described in each of the claims 1-12, with the characteristic that the above mentioned optomagnetic recording medium is equipped with a recording layer and a playback layer, and that magnetic information of the re-

cording layer is tranferred to the playback layer, and information is played back from the playback layer.

[Claim 14]

A recording device with the characteristic that a recording device for the recording of information in an optomagnetic recording medium is equipped with

a light source for irradiation of the optomagnetic recording medium by recording light, and

a magnetic field applying device for the application of a recording magnetic field, and

a modulator that modulates recording data in such a way that in the case that recording data are expressed by a data sequence that is constituted by bit data in the recording direction and bit data in the direction that is opposite to the recording direction, bit data with the direction that is opposite to the recording direction, are interposed between the respective bit data,

and that at least either the above mentioned recording light or the recording magnetic field is modulated, based on the signal from the said modulator.

[Claim 15]

The recording device that has been described in claim 14, with the characteristic that one information data among the above mentioned recording data is allotted to a combination of bit data in the above mentioned recording direction, and bit data in the direction that is opposite to the recording direction, and that the other information data is allotted to a combination of two bit data in the direction that is opposite to the recording direction.

[Claim 16]

A recording method with the characteristic that in the method of recording of an optomagnetic recording medium wherein information is recorded by irradiation of an optomagnetic recording medium that has been equipped with a recording layer by recording light under application of a magnetic field in the recording direction, a recording magnetic section is formed in the case

that information that continues for 2 bits or more, is recorded in the recording layer, in such a way that the group of recording magnetic sections that corresponds to the said information that continues for 2 bits or more, contains at least one magnetic section that has a magnetization in the direction that is opposite to the recording direction.

[Claim 17]

The recording method that has been described in claim 16, with the characteristic that the signal that is based on information that continues for 2 or more bits, is modulated in such a way that the group of recording magnetic sections that corresponds to the said information that continues for 2 bits or more, contains at least a magnetic section that has a magnetization in the direction that is opposite to the recording direction.

[Claim 18]

A recording method with the characteristic that in the method of recording of an optomagnetic recording medium wherein information is recorded in the recording layer by irradiation of an optomagnetic recording medium that has been equipped with a recording layer by recording light under application of a magnetic field in the recording direction,

a magnetic field in the recording direction with magnetic field strength H1 is applied in the case that a recording mark with mark length A is recorded in the above mentioned recording layer, and

a magnetic field in the recording direction with magnetic field strength H2 ($H2 \neq H1$) is applied in the case that a recording mark with mark length B ($B \neq A$) is recorded in the above mentioned recording layer.

[Claim 19]

The recording method that has been described in claim 18, with the characteristic that the above mentioned recording mark with mark length A is the shortest recording mark.

[Claim 20]

The recording method that has been described in claim 19,

with the characteristic that the above mentioned magnetic field strengths H1 and H2 satisfy H1 > H2.

[Claim 21]

The recording method that has been described in claims 19 or 20, with the characteristic that the above mentioned recording mark with mark length B is a recording mark of recording information that continues for 2 or more bits.

[Claim 22]

The recording method that has been described in claims 20 or 21, with the characteristic that in the case that the above mentioned recording mark with mark length B is recorded, the magnetic field in the recording direction is modulated.

[Claim 23]

The recording method that has been described in each of the claims 18 or 22, with the characteristic that in the case that the above mentioned recording marks with mark lengths A or B are recorded, the light intensity of the above mentioned recording light is modulated.

[Detailed description of the invention]

0001

[Field of technology whereto the invention belongs]

This invention pertains to a recording method and recording device whereby information is recorded in the recording layer of an optomagnetic recording medium, and with more details, it pertains to a recording method and recording device whereby recording marks that have the possibility of stable playback even with various mark lengths at the time of information playback, can be formed in the recording layer.

0002

[Existing technology]

Optical recording media such as optomagnetic recording media are known as external memories of computers etc. Because optomagnetic recording media can handle data with a large capacity, such as moving images and speech, they are frequently used as

recording media in the multimedia era. In optomagnetic recording media, usually the information is recorded by causing the '1' and '0' of bit information to correspond with the presence or absence of a recording mark, and as methods of recording of information in an optomagnetic recording medium, for instance the optical modulation method and the magnetic field modulation method are known.

0003

With the method of optical modulation, information is recorded by radiating laser light that has been modulated corresponding with the recording information, under application of a direct current magnetic field to the recording layer. Because with this method always information is recorded under application of a magnetic field in a fixed direction, it is necessary to carry out recording repair after erasion of former information, in the re-recording of information in a section wherein information has been recorded previously. With the method of magnetic field modulation, on the other hand, information is recorded by application of a magnetic field that has been turned into pulses, corresponding to the bit data, under radiation of direct current laser light to the recording layer. Because with this method, data can be recorded by inverting the direction of magnetization of the recording layer, corresponding to the '1' and '0' of the bit information, by the recording magnetic field, direct superscription is possible. Because direct current laser light is radiated, however, the form of the recording marks gets a crescent form that is long in the tangential direction of the medium, when the linear velocity increases, and this is a disadvantage on the point of playback signal processing.

0004

As a technique for improvement of the method of magnetic field modulation, the method of optomagnetic field modulation, wherein a magnetic field with a polarity that corresponds with the recording signal, is applied, under radiation of light, that has been converted to pulses, synchronized with the recording clock, is known. According to this method, the weak point of the method of magnetic field modulation is eliminated, and because very small recording magnetic sections are formed, recording

with a high density is possible.

0005

Information that has been recorded with a high density, however, leads to the situation that a number of recording magnetic sections are present inside the playback light spot, and these cannot be individually played back. That is to say that because the analytical capacity of the playback light is insufficient, the individual very small recording magnetic sections cannot be played back. Therefore, it was necessary to play back the very small recording magnetic sections with a diameter of the playback spot with the present size.

0006

As a method to solve this problem, for instance the magnetic super resolution technique (MSR) has been proposed in the Journal of the Magnetic Society of Japan, vol. 17, supplement no. S1, pp. 201 (1993). With this technique, it is possible to mask one magnetic section so that it is invisible, even if 2 recording magnetic sections are present in a playback light spot, and thus to effectively narrow the field of vision, and to playback the other recording magnetic section. When this technique is used, the analytical playback capacity can be improved without reduction of the actual playback light spot. Because, however, even if this technique of magnetic super resolution is used, the strength of the playback signal does not change, the C/N of the playback signal simply was low.

0007

In international public disclosure WO 98/02878, the present inventors disclosed an optomagnetic recording medium that has a layer for magnification and playback of magnetism and a recording layer on a substrate, and that, at the time of playback, transfers micro magnetic sections of the recording layer individually to the playback layer, and applies a playback magnetic field, and thereby can magnify the transferred magnetic sections and play them back. Because, according to this optomagnetic recording medium, the magnetic sections that have been transferred to the layer for magnification and playback of magnetism, are magnified to about the size of the light spot, the strength of

the playback signal is remarkably increased. This technique is called MAMMOS (Magnetic Amplifying Magneto-Optical System), and it solves the problems of the above mentioned technique of magnetic superresolution with respect to the playback C/N of the micro magnetic sections.

0008

[Problems that should be solved by the invention]

In the above mentioned MSR and MAMMOS, information of the recording layer is transferred to the playback layer with the use of the leaking magnetic field from the recording magnetic section of the recording layer, and thereafter, the information is read out from the playback layer. In the case that in such a system, recording magnetic section (recording mark) 227 that continues for 2 bits or more, as is shown in figure 2, is present in the recording layer, however, it appeared that the playback signal from continuous recording magnetic section 227 is less stable than that of the shortest recording magnetic section that is independently present. It is thought that the reason is that in the end sections and the central section of the continuous recording mark that has been formed in the recording layer, the sizes of the leaking magnetic fields are different, and that particularly the leaking magnetic field from the central section is weaker than the leaking magnetic field from the end sections, and that transfer of the information of the central section of the continous recording mark to the playback layer is difficult. Therefore, a problem was that for playback of respectively the shortest recording mark and a continuous recording mark, the power of the playback magnetic field and the playback light have to be stricly controlled, and the margin of the playback power is narrow.

0009

In official bulletin of patent disclosure 2-101659 (1990), a recording method that carries out recording of binary information by taking 2 of the smallest recording units whereby information is recorded, as 1 set, and differentiating the magnetization of the smallest recording units that form this set. Nothing, however, has been mentioned on the recording by splitting continuous recording magnetic sections in such a way that they

are constituted by magnetic sections with directions of magnetization that differ from each other.

0010

This invention has been performed in order to solve the problems of the above mentioned existing technology, and its aim is to offer a recording method that can form such recording marks in a recording layer that they can be transferrred in a reliable way to the playback layer at the time of playback of information, even in case of various mark lengths.

0011

Moreover, another aim of this invention is to offer a recording device that can carry out recording of continuous recording marks wherein stable playback properties are obtained, in a recording layer.

0012

[Means to solve the problems]

In accordance with the first situation of execution of this invention, a method with the characteristic that in a method of recording of optomagnetic recording media wherein information is recorded by irradiating an optomagnetic recording medium with recording light under application of a magnetic field in the recording direction, 1 bit of information is allotted to a combination of a magnetic section that has a magnetization in the recording direction and a magnetic section that has a magnetization in the direction that is opposite to the recording direction, or to a combination of 2 magnetic sections that have a magnetization in the direction that is opposite to the recording direction, and that in the case that 1 bit of information that consists of a combination of a magnetic section that has a magnetization in the above mentioned recording direction and a magnetic section that has a magnetization in the direction that is opposite to the recording direction, is recorded, continuing for 2 bits or more, the size of the recording magnetic sections is adjusted in such a way that the magnetic section that has a magnetization in the recording direction that is contained in the first bit of information, is shorter that the magnetic section that has a magnetization in the recording direction that is con-

tained in the second and higher order bits of information, is offered.

0013

In the recording of information in optomagnetic recording media, hitherto information was recorded by inverting the direction of magnetization of a magnetic section of the recording layer in the recording layer wherein the direction of magnetization has been given an orientation in one direction (initial direction), corresponding to the '0' and '1' of binary information. When, in the case that the '1' of the binary values is the information for recording, recording data continue for 2 bits or more (for instance '1111'), a long magnetic mark 227 is formed in the recording layer, as is shown in figure 2. With such a long magnetic mark 227, the strengths of the leaking magnetic fields in central section 228 and terminal section 229 of magnetic mark 227 are different, as has been mentioned in the column of the existing technology. Therefore, the optimum playback power for playback of information that is positioned in central section 228 of a continuous mark differs from the optimum playback power for playback of the information that is positioned in terminal section 229 of continuous mark 227 and the information of the shortest mark that is independently present, and playback of information with the same playback power was difficult.

0014

With the recording method of this invention, on the other hand, one part of a bit of information that consists of 2 values, for instance '1', is allotted to a combination of magnetic section 221 that has a magnetization in the direction of recording (upwards in the figure), and magnetic section 222 that has a magnetization with a direction that is opposite to the recording direction (downward in the figure), such as magnetic pattern 223, and the other part of the bit of information that consists of 2 values, for instance '0', is allotted to a combination of two magnetic sections that have a magnetization in the direction that is opposite to the recording direction, such as magnetic section pattern 224, as is shown in figure 3.

0015

Here, the recording direction shows either the vertically upward or downward direction to the film surface of the recording layer, and for convenience' sake, the vertically upward direction is assumed to be the recording direction in this detailed description, as is shown in figures 2-4. Moreover, the magnetic section that has a magnetization in the recording direction, is called the '↑ magnetic section', and the magnetic section that has a magnetization in the direction that is opposite to the recording direction (initializing direction or deleting direction), is called '↓ magnetic section'. Moreover, in the binary information (digital information) that is presented with '1' or '0', '1' is the recording information.

0016

By the recording method according to the first situation of this invention, continuous recording information, for instance '1111', is constructed as a magnetic pattern section that consists of ↑ magnetic sections and ↓ magnetic sections ('↑ ↓ ↑ ↓ ↑ ↓ ↑ ↓'). In other words, even in the case that continuous recording information is recorded, always a magnetic section that has a magnetization in the direction that is opposite to the recording direction, is present, neighbouring a (minimal) magnetic section that has a magnetization in the recording direction. Consequently, the size of the leaking magnetic field that is produced from a magnetic section that corrresponds with the recording information, is the same, irrespective of the way wherein a magnetic section that corresponds with the said recording information is present in the magnetic section pattern. Therefore, magnetization information can be transferred in a stable way to the playback layer, irrespective of the continuous length of the recording information. In this text, 1 bit is the minimal unit of binary information, for instance a data sequence that is expressed by '1' and '0', and at the time of playback, each '1' or '0' of 1 bit of information is read out.

0017

In the recording of information in the recording layer in the recording method of this invention, for instance the data '1' of 1 bit of binary information that is expressed by '1' or '0' is

converted to the code sequence '10', and the data '0' of 1 bit is converted to the code sequence '00', and based on these converted code sequences, at least either the recording light or the recording magnetic field may be modulated. That is to say that in the case that the recording data is '1011', it may be converted to '10001010'. From the converted code sequence, a recording signal with a waveform as is shown in figure 9, is produced, and based on this recording signal, the recording magnetic field may be modulated and applied.

0018

When, among the 2 magnetic sections (↑ magnetic section and ↓ magnetic section) that constitute 1 bit of recording information, the magnetic section that has a magnetization in the recording direction (↑ magnetic section) has length L1, and the magnetic section that has a magnetization in the direction that is opposite to the recording direction (↓ magnetic section) has length L2, in this invention L1/L2 preferably is in the range of 0.1-0.9. Here, the length of the magnetic section means the length of the magnetic section in the direction of the track. When length L2 of the ↓ magnetic section to length L1 of the ↑ magnetic section is 0.1 or more, a stable leaking magnetic field can be generated from these 2 magnetic sections. Moreover, when length L2 of the ↓ magnetic section to length L1 of the ↑ magnetic section is 0.9 or less, stable playback characteristics can be obtained when continuous recording information is recorded.

0019

Moreover, the size of the leaking magnetic field from an ↑ magnetic section usually depends on the size of the ↑ magnetic section and the hereto adjacent ↓ magnetic section. Therefore, the size of the leaking magnetic field from an ↑ magnetic section that corrresponds with the first bit of recording information is, because neighbouring hereto two ↓ magnetic sections are present, larger than the size of the leaking magnetic field from an ↑ magnetic section that corresponds with the second bit of recording information. In order to homogenize the leaking magnetic field from the magnetic section that corresponds with the very first bit of recording information and the second and high-

er order bits of recording information in the recording of recording information with 2 or more continuous bits, consequently, the size of the magnetic sections preferably is adjusted in such a way that the ↑ magnetic section that corresponds with the very first bit of recording information is shorter than the ↓ magnetic section that corresponds with the second and higher order bits of recording information.

0020

According to the second situation of this invention, a recording method with the characteristic that in the method of recording of an optomagnetic recording medium wherein information is recorded by irradiation of the recording layer of the optomagnetic recording medium with recording light while a magnetic field in the recording direction is applied, at least either the recording light or the recording magnetic field are modulated, so that the domain of the recording layer that corresponds to one side of 1 bit of binary information, is constituted by a magnetic section that has a magnetization in the recording direction, and a magnetic section that has a magnetization in the direction that is opposite to the recording direction and the domain of the recording layer that corresponds with the other side of 1 bit of binary information, is constituted by 2 magnetic sections that have a magnetization in the direction that is opposite to the above mentioned recording direction, and when the length of the magnetic section that has a magnetization in the above mentioned recording direction is L1, and the length of the magnetic section that has a magnetization in the direction that is opposite to the above mentioned recording direction is L2, the size of the recording magnetic sections is modulated so that L2/L1 is in the range of 0.1-0.9, is offered.

0021

In the recording method according to the second situation of this invention, at least either the recording light or the recording magnetic field is modified, so that the domain that corresponds with the '1' in the bit information that is presented by '1' and '0', is constituted by a pattern of two magnetic sections ('↑ ↓') that consists of a ↑ magnetic section and a ↓ magnetic section, and the domain that corresponds with '0', is con-

stituted by a pattern of magnetic sections ('↓ ↓') that consists of two ↓ magnetic sections. When, among the two magnetic sections (↑ magnetic section and ↓ magnetic section) that constitute 1 bit of recording information, the length of the magnetic section that has a magnetization in the recording direction (↑ magnetic section) is L1, and the length of the magnetic section that has a magnetization in the direction that is opposite to the recording direction (↓ magnetic section) is L2, L2/L2 is adjusted in the range of 0.1-0.9. Hereby, stable transfer of magnetization information of the recording layer to the playback layer is possible, irrespective of the continuous length of the recording information, in the same way as has been described for the above mentioned first situation, even if continuous recording information has been formed in the recording layer.

0022

According to the third situation of this invention, a recording method with the characteristic that in a recording method wherein information is recorded by formation of magnetic sections with different directions of magnetization in the recording layer of the optomagnetic recording medium, one information of an information that consists of 2 values is allotted to a sequence of magnetic sections that consists of 2 magnetic sections with mutually different directions of magnetization, and the other information of an information that consists of 2 values is allotted to a sequence of magnetic sections that consists of 2 magnetic sections with the same direction of magnetization, and that the ratio of the length of the other magnetic section to the one magnetic section among the 2 above mentioned magnetic sections with different directions of magnetization, is in the range of 0.1-0.9, is offered.

0023

In the recording method according to the third situation of this invention, a sequence of magnetic sections that consists of 2 magnetic sections with different directions of magnetization, is allotted to one of the bit information that consists of the 2 values '1' and '0', for instance the '1', and a sequence of magnetic sections that consists of 2 magnetic sections with the same direction of magnetization, is allotted to the '0'. When

for instance the magnetic section that has a magnetization in the recording direction is the ↑ magnetic section, and the magnetic section that has a magnetization that is upside down parallel to the ↑ magnetic section, is the ↓ magnetic section, a magnetic section sequence ↑↓ that consists of a ↑ magnetic section and a ↓ magnetic section, is allotted to the '1' of the binary information, and a magnetic section sequence ↓↓ that consists of 2 ↓ magnetic sections, is allotted to the '0' of the binary information. The ratio of the length of the other magnetic section to the one magnetic section among the 2 magnetic sections with different directions of magnetization is adjusted in the range of 0.1-0.9. By the fact that here the '1' of the binary information is made to correspond with one of the bit information that consists of 2 values, that has been described in the above mentioned first situation, and the '0' of the binary information is made to correspond with the other of the bit information that consists of 2 values, the same results as in the first situation come to be obtained.

0024

According to the fourth situation of this invention, a recording method with the characteristic that in case of recording of recording information that continues for 2 or more bits, in a method of recording of an optomagnetic recording medium wherein information is recorded in the recording medium by irradiation of an optomagnetic recording medium that has been equipped with a recording layer, by recording light under application of a magnetic field in the recording direction, the information is recorded in such a way that recording information of at least 1 bit is constituted by a magnetic section that has a magnetization in the recording direction and a magnetic section that has a magnetization in the direction that is opposite to the recording direction, is offered.

0025

According to the fifth situation of this invention, a recording method with the characteristic that in case of recording of recording information that continues for 2 or more bits, in a method of recording of an optomagnetic recording medium wherein information is recorded in the recording medium by irradiation

of an optomagnetic recording medium that has been equipped with a recording layer, by recording light under application of a magnetic field in the recording direction, at least either the above mentioned recording magnetic field or the recording light are modified in such a way that a magnetic section that has a magnetization in the direction that is opposite to the recording direction is formed inside the recording domain of the recording layer that corresponds with recording information of 1 bit, is offered.

0026

In the case that independent recording information that corresponds with 1 bit is recorded with the recording method according to the fourth and fifth situation of this invention, this recording information is, as is shown in figure 4, constituted only by isolated recording magnetic section 441 that has a magnetization in the recording direction, and in the case that recording information that continues for 2 or more bits, is recorded, they are constituted by recording magnetic section 442 that has a magnetization in the recording direction and magnetic section 443 that has a magnetization that is opposite to the recording direction. Hereby, a homogeneous leaking magnetic field is obtained, irrespective of the position of the magnetic sections that constitute this recording information, even in the case of continuous information, and the margin of the playback power is not narrowed by the length of the successive recording magnetic sections.

0027

According to the sixth situation of this invention, a recording device wherein a recording device for recording of information in an optomagnetic recording medium is equipped with a light source for irradiation of the optomagnetic recording medium by recording light, and a magnetic field applying device for application of a recording magnetic field, and a modulator that modulates recording data in such a way that in the case that recording data are presented by a data sequence that is constituted by bit data in the recording direction and bit data in the direction that is opposite to the recording direction, bit data with the direction that is opposite to the recording direction

are inserted between the respective bit data, and wherein at least either the above mentioned recording light or the recording magnetic field are modulated, based on the signal from the said modulator, is offered.

0028

In the case that recording data are presented by a data sequence that consists of bit data '1' in the recording direction and bit data '0' in the direction that is opposite to the recording direction, the modulator of the recording device of this invention modulates the recording data in such a way that bit data with the direction that is opposite to the recording direction, are inserted between the respective bit data. In other words, the code of one bit data '1', that is recording information, is code converted to the code sequence '10', and the one bit data '0' is code converted to the code sequence '00', and at least either the recording light or the recording magnetic field can be modulated, based on this code converted code sequence. By the use of the recording device of this invention, the recording methods according to the first to fifth situations of this invention can be executed, and a homogeneous leaking magnetic field can be generated, irrespective of the length of continuation of the recording information and the position of the recording magnetic section. Therefore, the recording device of this invention is suited for recording in optomagnetic recording media that have been equipped with a recording layer and a playback layer wherein the information of magnetization of the recording layer is transferred.

0029

According to the seventh situation of this invention, a recording method with the characteristic that in the recording of information that continues for 2 or more bits in the recording method of an optomagnetic recording medium that records information by the fact that an optomagnetic recording medium that has been equipped with a recording layer, is irradiated by recording light under application of a magnetic field in the recording direction, information is recorded in such a way that in the recording domain of the recording layer that corresponds with the said information that continues for 2 or more bits, contains at

least a magnetic section that has a magnetization in the direction that is opposite to the recording direction, is offered.

0030

In the case that continuous information is recorded in the recording method of the seventh situation of this invention, a continuous recording mark is split into a number and recorded, so that the sequence of magnetic sections that constitute the continuous recording information (continuous recording mark) contains at least one magnetic section (recording mark) that has a magnetization in the direction that is opposite to that of this sequence of magnetic sections. In order to cause the continuous recording mark that corresponds with recording information that continues for 2 or more bits, to contain a magnetic section wherein the direction of magnetization is opposite, for instance the recording signal that is based on this recording information, may be modulated. The length of the magnetic sections (mark length) with different directions of magnetization that are present in the continuous magnetic section, can be an optional length, and is not limited to the length of a 1 bit section.

0031

According to the eighth situation of this invention, a recording method with the characteristic that in the recording of a recording mark with mark length A in the recording layer in the recording method of an optomagnetic recording medium that records information in a recording layer by the fact that an optomagnetic recording medium that has been equipped with a recording layer, is irradiated by recording light under application of a magnetic field in the recording direction, a magnetic field in the recording direction with a magnetic field strength H1 is applied, and that in the case that a recording mark with a mark length B ($B \neq A$) is recorded in the recording layer, a magnetic field in the recording direction with a magnetic field strength H2 ($H2 \neq H1$) is applied, is offered.

0032

In the recording method that is the eighth situation of this invention, the magneic field strength of the recording magnetic

field is modulated, corresponding to the length of the recording mark that is formed in the recording layer. That is to say that in the case that a recording mark with mark length A is recorded, a recording magnetic field with magnetic field strength H1 is applied, and in the case that a recording mark with mark length B is recorded, a recording magnetic field with magnetic field strength H2, that differs from H1, is applied. In the case that for instance the recording mark with mark length A is the shortest recording mark, a recording magnetic field with the same magnetic field strength H1 as in the past is applied and a recording mark is formed in the recording layer. In the case of a recording mark with mark length B (continuous recording mark), a recording magnetic field with a magnetic field strength H2, that is a smaller strength than H1, is applied, and a recording mark is formed in the recording layer. The recording mark with mark length B that has been recorded with a weaker magnetic field strength, has a state wherein magnetic sections in the recording direction and magnetic sections with the opposite direction are mixedly present (state wherein magnetic sections in the recording direction have been scattered). Since in the situation of mixed presence of magnetic sections in the recording direction and magnetic sections in the opposite direction, the leaking magnetic fields from all positions have a sufficient magnetic field strength, the front edge and the rear edge of the continuous recording mark also have sufficient magnetic fields, even at a distance from the center, and the leaking magnetic fields can be homogenized across the whole of the continuous recording mark.

0033

[Situation of execution of the invention]

Below, the situation of execution of the recording method and the recording device of this invention and examples of execution are described, referring to figures, but this invention is not limited hereto.

0034

Situation of execution 1.

Figure 1 schematically shows the construction of a recording device according to this invention. Recording device 101 mainly

consists of a laser light radiating section for irradiation of optomagnetic recording medium 100 with light that has been converted to pulses with a period that has been synchronized with code data, and a magnetic field applying section that applies a magnetic field that has been controlled at the time of recording and playback on optomagnetic recording medium 100, and a signal processing system that detects and processes signals from optomagnetic recording medium 100. In the laser light radiating section, laser 22 is connected with laser driving circuit 32 and recording pulse amplitude/phase adjusting circuit 51 (RC-PPA), and laser driving circuit 32 receives a signal from recording pulse amplitude and phase adjusting circuit 51, and controls the laser pulse amplitude and phase of laser 22. Recording pulse amplitude/phase adjusting circuit 51 receives a clock signal that will be discussed below, from PLL circuit 39, and emits a first sync signal for the adjustment of the phase and pulse amplitude of the recording light.

0035

In the magnetic field applying section, magnetic coil 29 that applies a magnetic field, is connected with magnetic coil driving circuit (M-DRIVE) 34, and at the time of recording, magnetic coil driving circuit 34 receives data that have been code-converted via phase adjusting circuit (RE-PA) 31 from modulator 30 that converts the recorded data to a prescribed code, and controls magnetic coil 29. At the time of playback, on the other hand, it receives a clock signal that will be discussed below, from PLL circuit 39, and generates a second sync signal for adjustment of the phase and pulse amplitude via playback pulse amplitude/phase adjusting circuit (RP-PPA) 131, and controls magnetic coil 29, based on the second sync signal. For switching of the signal that is inputted in magnetic coil driving circuit 34 at the time of recording and the time of playback, recording/playback switcher (RC/RP SW) 134 is connected with magnetic coil driving circuit 34.

0036

In the signal processing system, first polarization prism 25 has been arranged between laser 22 and optomagnetic recording medium 100, and at one side thereof, second polarization prism

251 and detectors 28 and 281 have been arranged. Detectors 28 and 281 are connected to both subtractor 302 and adder 301, respectively via I/V converters 311 and 312. Adder 301 is connected with PLL circuit 39 via clock extraction circuit (CSS) 37. Subtractor 302 is connected with decoder 38 via sample and hold (S/H) circuit 41 that holds the signal, synchronized with the clock, and A/D converter circuit 42 that carries out analogue/digital conversion, synchronized with the same clock, and binarizing signal processing circuit (BSC) 43.

0037

In the construction of the above mentioned apparatus, the light that has been radiated from laser 22 is converted to parallel light by collimator lens 23, and via polarization prism 25, it is focussed on optomagnetic recording medium 100 by objective lens 24. The reflected light from disk 100 is directed to polarization prism 251 by polarization prism 25, and after passage through half wavelength plate 26, it is split into 2 directions by polarization prism 251. The split light is respectively focussed by detection lens 27 and guided to photodetectors 28 and 281. Here, pits for formation of tracking error signal and clock signal have been formed in advance on optomagnetic recording medium 100. The signal that shows the reflected light from the pit for formation of the clock signal is detected by detectors 28 and 281, and thereafter extracted in clock extracting circuit 37. Subsequently, a data channel clock is generated in PLL circuit 39 that has been connected with clock extracting circuit 37.

0038

In the case of data recording, laser 22 is modulated with a fixed frequency so that it gets the 1/2 period of the data channel clock by laser driving circuit 32, and continuous pulse light with a narrow amplitude is radiated, and the data recording area of turning (rotating) optomagnetic recording medium 100 is locally heated with equal distances. Moreover, the data channel clock controls modulator 30 of the magnetic field application section, and a data signal with the standard clock period is generated. The recording data are modulated by modulator 30, viz., code-converted. For instance '1', that is recording infor-

mation among the recording data, is converted to '10', and '0' is converted to '00'. Moreover, the various codes after code conversion are modulated by modulator 30 so that they are forwarded to phase modulating circuit 31 with 1/2 of the period of the data channel clock. The '1' or '0' of the code data signal after code conversion are forwarded to phase adjusting circuit 31, and after phase adjustment, forwarded to magnetic coil driving circuit 34. By phase adjusting circuit 31, the phase is adjusted in such a way that particularly in the case of a recording information sequence with successive recording data '1', such as '111', the periods of the '1' and the '0' in the '10' of the code data signal that corresponds with the initial recording data '1', become the same period, and the phase is adjusted in such a way that the '1' in the code data signal '10' that corresponds with the next recording data '1', corresponds with 3/4 period of the data channel clock, and the '0' becomes 1/4 period of the data channel clock. Magnetic coil driving circuit 34 controls magnetic field coil 29 and applies a magnetic field with a polarity that corresponds converted code data signal to the heated section of the data recording area of optomagnetic recording medium 100.

0039

Subsequently, a schematic cross section of optomagnetic recording medium 100 wherein information is recorded with the use of this recording device 101, is shown in figure 5. Optomagnetic recording medium 100 is an optomagnetic recording medium for MAMMOS (Magnetic Amplifying Magneto-Optical System), and it has a structure wherein dielectric layer 2, magnetic magnification and playback layer 3, non-magnetic layer 4, recording layer 5 and protective layer 6 have been successively layered on transparent substrate 1. The optomangetic recording medium with this structure is based on the principles of MAMMOS (Magnetic Amplifying Magneto-Optical System) that has been proposed by the present applicant, and it can transfer and magnify the micro recording magnetic sections of the recording layer to the magnetic section magnifying and playback layer under application of a playback magnetic field. Because details of the principles of MAMMOS have been described in international public disclosure WO 98/02878, we can refer thereto.

0040

In the construction that is shown in figure 5, a freely chosen substrate that is transparent, such as for instance ones wherein transparent resin materials such as polycarbonate and amorphous polyolefins have been moulded to the desired form, and ones wherein a transparent resin film whereto the desired preformat pattern has been transferred, has been glued to one surface of a glass plate that has been moulded to the desired form, can be used as transparent substrate 1. Dielectric layer 2 is established in order to cause multiple interference of light beams for playback inside the film, and to really increase the Kerr rotary angle, and it can be formed with the use of a material with a higher refractive index than transparent substrate 1, for instance an inorganic dielectric that consists of SiN. Protective layer 6 is a layer to protect films 3-5 that are layered between transparent substrate 1 and protective layer 6, against bad chemical influences such as corrosion, and it consists for instance of a SiN film or carbon film. Recording layer 5 is a film with vertical magnetization, that shows anisotropy of vertical magnetism at temperatures above room temperature, and amorphous alloys of rare earths and transition metals, such as for instance TbFeCo, DyFeCo and TbDyFeCo are most preferred, but also other well known optomagnetic recording materials such as an alternating laminate of Pt films and Co films and garnet oxide magnetic materials, can be used. Non-magnetic layer 4 consists for instance of dielectrics such as SiO_2, AlN and SiN, and metals such as Al, AlTi, Au, Cu, AuAl and AgAl, or laminates wherein these metals and dielectrics have been laminated. Magnetic section magnifying and playback layer 3 is a film with vertical magnetization that shows a vertical magnetization at or above room temperature, and in order to obtain a good playback signal at the time of playback, it can be constructed with the use of such a magnetic material, such as for instance GeFeCo, that the Kerr rotary angle increases at the maximum temperature of the medium when it is irradiated by playback light.

0041

The above mentioned dielectric layer 2, magnetic section magnifying and playback layer 3, non-magnetic layer 4, recording layer 5 and protective layer 6 can for instance be formed by a

dry process such as continuous sputtering by a magnetron sputtering device.

0042

Optomagnetic recording medium 100, that has this construction, is mounted in recording device 101 in such a way that laser light is radiated from the side of substrate 1, and information is recorded. The wavelength of the laser of the optical head of recording device 101 is 680 nm, and the numerical aperture NA of the objective lens is 0.55. The recording of data was carried out with the use of a light pulse electric field modulating recording system, that carries out recording by modulating an external magnetic field that has been modulated to a prescribed code data signal by a modulator, with $\pm$ 200 (Oe), under radiation of a laser beam on a pulse with a fixed period, with a linear speed of 2.5 m/sec, and with a 30% duty of the laser light pulse. Figure 6 shows a timing chart of the recording laser light pulse and the recording external magnetic field with respect to the recording clock. The upper side of figure 6 shows the pattern of micro recording magnetic sections that have been formed by this recording method. The micro recording magnetic sections that are shown by black circles, correspond to code data signal '1' after the above mentioned conversion, and their diameter is 0.2 μm. Moreover, the the recording magnetic section of the very first bit of continuous recording data was formed with a diameter of 0.2 μm, and that of the second and higher order bits with a diameter of 0.3 μm.

0043

Subsequently, as has been mentioned above, the optomagnetic recording medium wherein information had been recorded, was played bak with the use of a playback device. In this playback of information, playback laser light is radiated, synchronized with the playback clock, to the individual recorded magnetic sections, and the playback magnetic field was modulated in the form of pulses, and applied in such a way that it was made synchroneous with the playback clock. Moreover, the sample and hold timing of the playback signal coincided with the modulation timing of the magnetic field. By the fact that now for recording information wherein the pattern of the recording information is

'1', '11' and '1111' (corresponds with a length of 0.4 μm, 0.8 μm and 1.6 μm when it is calculated as the mark length by the existing recording method), the playback laser light and playback magnetic field are modified to various powers, a playback domain that has the possibility of playback of information was prepared. The results are shown in the graph of figure 7.

0044

As is clear from the graph of figure 7, it is shown that a domain that can playback the whole of the recording information of the respective recording patterns (lengths of recording marks), is extremely wide, and the playback power margin is extremely wide. Consequently, even if the information that is recorded by the recording device of this invention has various recording patterns, stable information playback is possible.

0045

In an optomagnetic recording medium that has been produced in situation of execution 1 of an example for comparison, recording information with the recording patterns '1', '11' and '1111' were recorded with the existing method wherein the recording information '1' of 1 bit is formed with a magnetic section in the recording direction, and the other information '0' of 1 bit is constructed with a magnetic section in the direction that is opposite to the recording direction. The recording information with the recording patterns '1', '11' and '1111' were respectively formed with mark lengths of 0.4 μm, 0.8 μm and 1.6 μm. The recording information with these mark lengths was played back in the same way as in the example of execution, and a playback domain that can play back the information, was prepared. The results are shown in the graph of figure 8. As is clear from this graph, the playback domain to the recording pattern '1111' (mark length 1.6 μm) is narrow, and has shifted to the high power side. Moreover, it shows that the domain that can playback the whole of the recording marks with a mark length of 0.4 μm, 0.8 μm and 1.6 μm, is extremely small, and that the playback power margin is extremely narrow.

Second situation of execution.

In this situation of execution, the recording method according to the eighth situation of this invention is described in the concrete. Figure 10 schematically shows the dependence of the form of the recording magnetic section of the optomagnetic disc from the strength of the recording magnetic field. In figure 10, disc A is an optomagnetic recording medium that has been equipped with a silicon nitride layer with a film thickness of 60 nm, a TbFeCo recording layer with a film thickness of 8 nm, and adjuvant recording layer of Pt84Co16 with a film thickness of 40 nm, and a silicon nitride layer with a film thickness of 60 nm on a polycarbonate substrate. Disc B is an optomagnetic recording medium that has been equipped with a silicon nitride layer with a film thickness of 60 nm, a TbFeCo recording layer with a film thickness of 8 nm, a silicon nitride layer with a film thickness of 60 nm, and an Al alloy layer with a film thickness of 50 nm on a polycarbonate substrate. At the lower side of figure 10, an outline of the recording magnetic section that is observed in disc A and disc B, is shown. In this outline, a number of micro magnetic sections are formed inside the domain wherein recording should be carried out (domain that reaches the temperature at which recording is possible), that is shown with a dotted line, and these micro magnetic sections gradually come to occupy the above mentioned domain with increasing strength of the recording magnetic field. In the table of figure 10, the situation of occupation of the above mentioned domain by the micro magnetic sections in disc A and disc B as compared with the recording magnetic field is shown and it shows the situation wherein 2 tracks, viz. 2 recording magnetic sections are formed in each disc. As is clear from disc A in figure 10, absolutely no recording magnetic sections and micro magnetic sections are formed in the case that the recording magnetic field is small. In disc B, an inversion of magnetization of the micro magnetic section that is so small that it appears in a wormy state inside the contour of the recording magnetic section, is generated. Moreover, when the recording magnetic field increases, many micro magnetic sections are formed inside the contour of the recording magnetic section, and when a sufficient recording magnetic field is applied, the micro magnetic sections

gather and a solid recording magnetic section is formed. In this way, the recording magnetic section that is formed gets a state of mixed presence of magnetic sections in the recording direction and magnetic sections in the opposite direction thereof (state wherein magnetic sections in the recording direction have been scattered), when the magnetic field strength of the recording magnetic field that is applied on the recording layer, is small. When a continuous recording mark is formed, therefore, a continuous recording mark can be brought in a state of mixed presence of magnetic sections with the recording direction and magnetic sections with the opposite direction thereof, by weakening the strength of the magnetic field that is applied on the recording layer. Since in the situation of mixed presence of magnetic sections with the recording direction and magnetic sections with the opposite direction thereof, a sufficient leaking magnetic field is obtained from any position, the leaking magnetic field from the central section of the continuous recording mark increases more than in the past. This can be explained also from a simulaton of formation of magnetic sections that pertains to the optomagnetic recording as is shown in figure 11, and the same recording can also be carried out with the optomagnetic recording medium for MAMMOS. The simulation of figure 11 schematically shows the results in the case of formation of a continuous recording mark with a mark length of 3 μm. Moreover, in the simulation results of figure 11, the black domains are domains that consist of magnetic sections that have a magnetization in the recording direction, and the white domains are domains that consist of magnetic sections that have a magnetization in the direction that is opposite to the recording direction.

0047

From the above mentioned results, it is clear that a recording magnetic field with a strength that differs from that in the case that the shortest recording mark is recorded, may be applied in the formation of continuous recording marks in such a way that a state of mixed presence of magnetic sections in the recording direction and magnetic sections in the opposite direction thereof is obtained. As the recording method, the method of recording with magnetic field modulation and the method of recording with light pulse magnetic field modulation can be used.

On the optomagnetic recording medium, for instance a recording magnetic field with a timing as is shown in figure 12a may be applied. Moreover, in order to make the contour of the edge section of the continuous recording mark conspicuous, it is for instance possible, as is shown in figure 12b, to make a strong recording magnetic field in the case that the edge section of a continuous recording mark is formed, and to make the recording magnetic field weak in other sections. Hereby, it is possible that magnetic sections in the recording direction are made to agglutinate(?) only in the edge section of the recording mark, and that in the central section of the continuous mark, a state of mixed presence of magnetic sections in the recording direction and magnetic sections in the direction that is opposite to the recording direction is obtained. The result thereof is that it is possible that the leaking magnetic field from the center of the continuous recording mark is increased. Because it is therefore, for instance in the case that an optomagnetic recording medium for MAMMOS that has been equipped with a magnetic section magnifying and playback layer, possible that the information in the center of the continuous recording mark is reliably transferred and magnified to the magnetic section magnifying and playback layer, playback errors in the playback of the central section of the continuous recording mark are greatly reduced.

0048

When now an optical recording medium for MAMMOS has been played back, it is clear that playback errors in the central section of the continuous recording mark are produced when the mark length of this continuous recording mark is longer than a prescribed length. In the case that the shortest mark is extremely short, information to obtain a sufficient leaking magnetic field from the central section can be played back, even if it is a continuous recording mark, and playback errors are only produced in continuous recording marks that are longer than the above mentioned prescribed length. In such cases, recording may be carried out with modification of the magnetic field strength of the recording magnetic field only in the case that a continuous recording mark that is longer than the prescribed length, is formed.

0049

Above, situations of execution of the recording method and recording device of this invention have been described, but this invention is not limited to the above mentioned situations of execution. In the first situation of execution, for instance an optomagnetic recording medium that has a layered structure of a substrate/dielectric layer/playback layer/non-magnetic layer/recording layer/protective layer was used as the optomagnetic recording medium wherein information is recorded, and information was recorded by radiating recording light from the side of the substrate, but it is also possible to adopt a situation wherein an optomagnetic recording medium that has a layered structure of a substrate/dielectric layer/recording layer/non-magnetic layer/playback layer/protective layer is used and information is recorded by radiating recording light from the side of the protective layer.

0050

Moreover, in the first situation of execution, an optomagnetic recording medium for MAMMOS was produced as the optomagnetic recording medium, but it is also possible to carry out recording with the use of an optomagnetic recording medium for MSR.

0051

Moreover, in the formation of a continuous recording mark recording layer in the second situation of execution, the magnetic field strength of the recording magnetic field was controlled in such a way that it is weaker than in the case that the shortest recording mark is recorded, but it is for instance also possible to record information, controlling the light strength of the recording light in such a way that the light strength of the recording light that is radiated in the formation of a continuous recording mark in the recording layer, is weaker than in the case that the shortest recording mark is recorded.

0052

[Results of the invention]

Because, if information is recorded with the use of the recording method of this invention, as has been described above, even in case of continuous recording information, a homogeneous

leaking magnetic field is obtained from the recording mark that corresponds with the respective recording informaton of this continuous recording information, it is extremely suited as a method that transfers magnetization information that has been recorded in a recording layer in the way of MAMMOS and MSR, to a playback layer, and records information in an optomagnetic recording medium of the type that plays back information from the playback layer.

0053

Moreover, if information is recorded with the use of the recording device of this invention, stable and reliable transfer of recording information to the playback layer is possible, irrespective of the recording pattern, and in addition, the power margin at the time of playback can be made wider than in the past.

[Brief description of the figures]

[Figure 1]

shows an outline of the construction of the recording device of this invention.

[Figure 2]

shows a cross section of a magnetic mark that is formed in the recording layer by the existing recording method, and an outline of the situation of the leaking magnetic field from the magnetic mark.

[Figure 3]

shows a cross section of the magnetic mark that is formed in the recording layer by the recording method of this invention, and an outline of the situation of the leaking magnetic field from the magnetic mark.

[Figure 4]

shows an outline of the situation of splitting and forming continuous magnetic marks by the recording method of this invention, and of the situation of the leaking magnetic field from the split magnetic mark.

[Figure 5]

shows the construction of the cross section of the optomagnetic recording medium that was produced in an example of execu-

tion.

[Figure 6]

is a timing chart that shows the correlation of the recording laser light pulses, recording external magnetic field and recording magnetic section of the recording method of this invention.

[Figure 7]

shows the playback domain for recording marks with various recording patterns that have been recorded with the use of the recording device of this invention.

[Figure 8]

shows the playback domain for recording marks with various recording patterns that have been recorded with the existing recording method.

[Figure 9]

is a figure for the explanation of the outline of the recording method of this invention, and it shows the correlation of the recording data and code converted code sequence, and recording signal that is based on the converted code sequence.

[Figure 10]

shows a scheme of the situation wherein the form of the recording magnetic section that has been formed in the recording layer of the optomagnetic recording medium, depends on the strength of the recording magnetic field.

[Figure 11]

shows a scheme of the results of simulation of the correlation of the strength of the recording magnetic field and the situation of the magnetic section that constitutes a continuous recording mark.

[Figure 12]

Figure 12a is an example of a timing chart when the magnetic field strength of the recording magnetic field has been modulated in accordance with the length of the recording mark, and figure 12b shows an example wherein the strength of the magnetic field has been modulated stepwise in the case that a continuous recording mark is formed.

[Explanation of the symbols]

1 substrate

2 dielectric layer

3	playback layer
4	non-magnetic layer
5	recording layer
6	protective layer
30	modulator
221	magnetic section that has a magnetization in the recording direction
222	magnetic section that has a magnetization in the direction that is opposite to the recording direction
223, 224	magnetic section patterns
100	optomagnetic recording medium
101	recording device

である。

【００５１】また、実施形態２では、連続記録マークを記録層に形成する際に、記録磁界の磁界強度を、最短記録マークを記録する場合よりも弱くなるように制御したが、例えば、連続記録マークを記録層に形成する際に照射する記録光の光強度が、最短記録マークを記録する場合よりも弱くなるように、記録光の光強度を制御して情報を記録することも可能である。

【００５２】

【発明の効果】以上説明してきたように、本発明の記録方法を用いて情報を記録すれば、連続した記録情報であっても、その連続記録情報のそれぞれの記録情報に相当する記録マークから均一の漏洩磁界が得られるので、ＭＡＭＭＯＳやＭＳＲのように記録層に記録された磁化情報を再生層に転写して再生層から情報を再生するタイプの光磁気記録媒体に情報を記録する方法として極めて好適である。

【００５３】また、本発明の記録装置を用いて情報を記録すれば、記録情報を記録パターンによらず安定して確実に再生層に転写することができ、しかも再生時のパワーマージンは従来よりも広くすることが可能となる。

【図面の簡単な説明】

【図１】本発明に従う記録装置の概略構成を示す図である。

【図２】従来の記録方法により記録層に形成される磁気マークの断面図と磁気マークからの漏洩磁界の様子を概念的に示す図である。

【図３】本発明に従う記録方法により記録層に形成される磁気マークの断面図と磁気マークからの漏洩磁界の様子を概念的に示す図である。

【図４】本発明に従う記録方法により連続した磁気マークを分割して形成した様子と分割された磁気マークからの漏洩磁界の様子を概念的に示す図である。

【図５】実施例で作製した光磁気記録媒体の断面構造を示す図である。

【図６】本発明に従う記録方法の記録レーザー光パルス、記録外部磁界及び記録磁区の関係を示すタイミングチャートである。

【図７】本発明の記録装置を用いて記録された種々の記録パターンの記録マークに対する再生領域を示す図である。

【図８】従来の記録方法により記録された種々の記録パターンの記録マークに対する再生領域を示す図である。

【図９】本発明の記録方法の概略について説明するための図であり、記録データと、コード変換されたコード列と、変換されたコード列に基づく記録信号との関係を示す図である。

【図１０】光磁気記録媒体の記録層に形成される記録磁区形状が記録磁界の強度に依存する様子を模式的に示す図である。

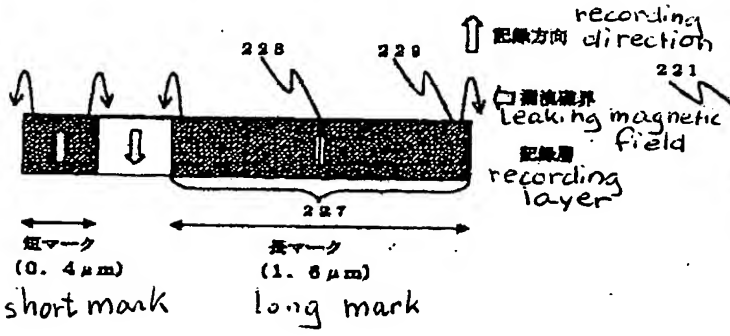
【図１１】記録磁界強度と連続記録マークを構成する磁区の様子との関係のシミュレーション結果を模式的に示す図である。

【図１２】図１２（ａ）は、記録マーク長に応じて記録磁界の磁界強度を変調させた時のタイミングチャートの一例であり、図１２（ｂ）は、連続記録マークを形成する際に磁界強度を段階的に変調した例を示す。

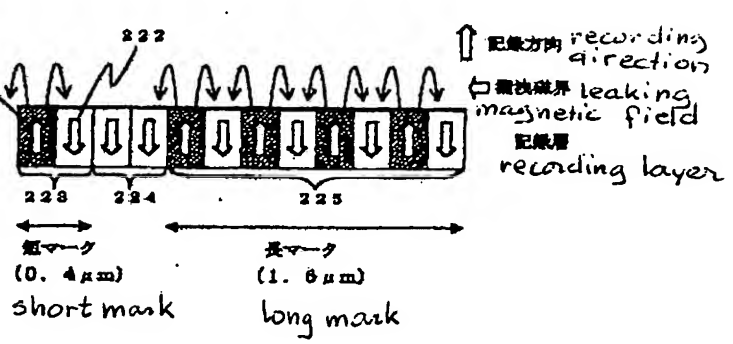
【符号の説明】

１　基板
２　誘電体層
３　再生層
４　非磁性層
５　記録層
６　保護層
３０　変調器
２２１　記録方向の磁化を有する磁区
２２２　記録方向と逆方向の磁化を有する磁区
２２３、２２４　磁区パターン
１００　光磁気記録媒体
１０１　記録装置

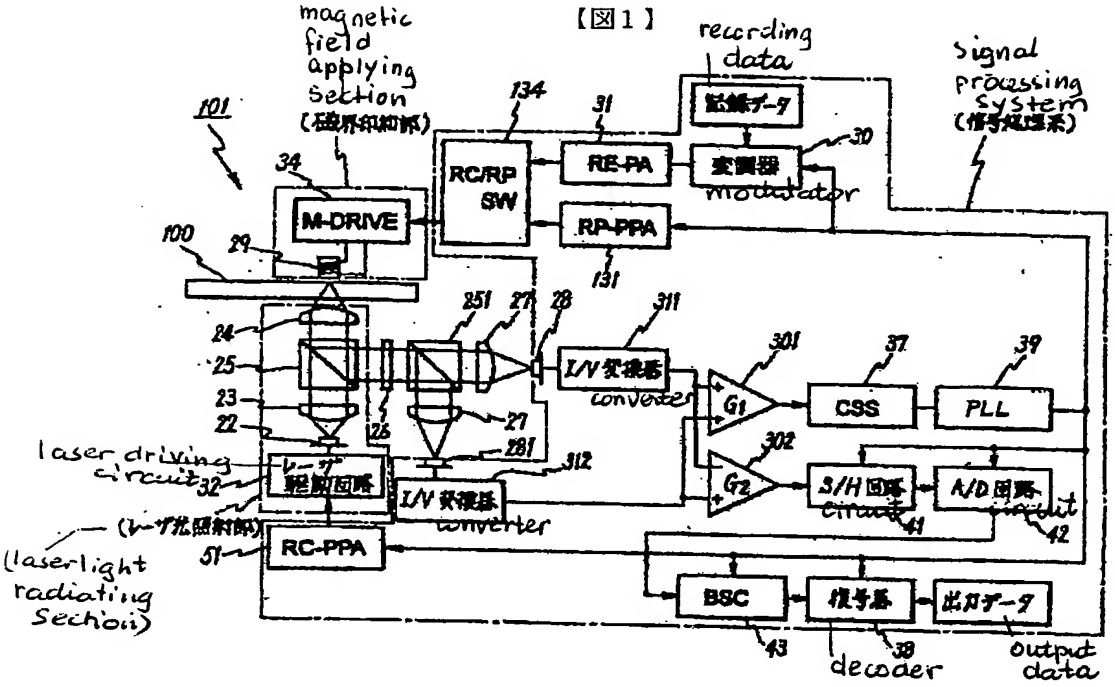
【図２】



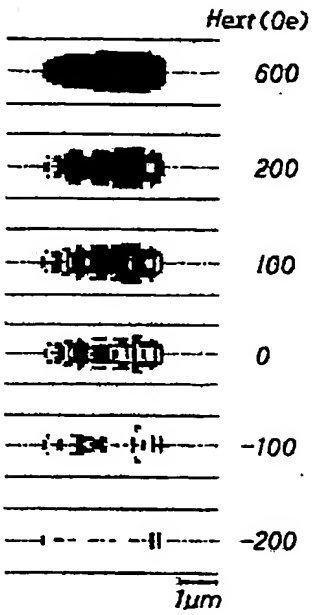
【図３】



【図1】



【図11】



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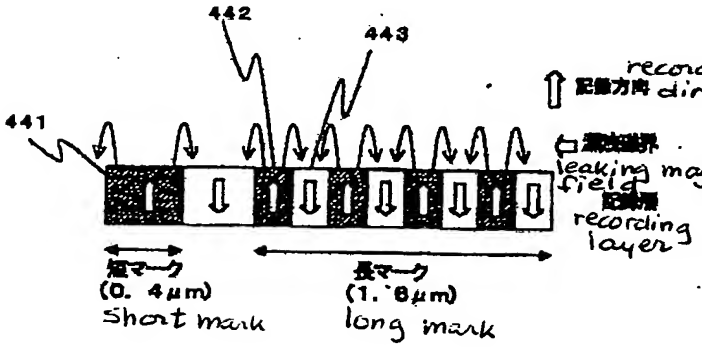
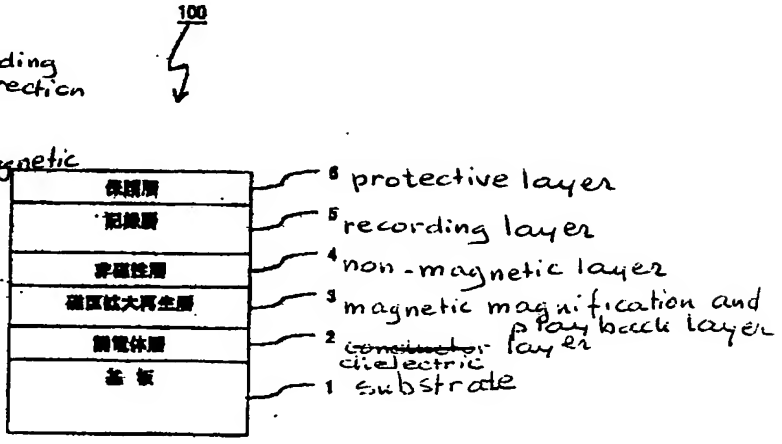
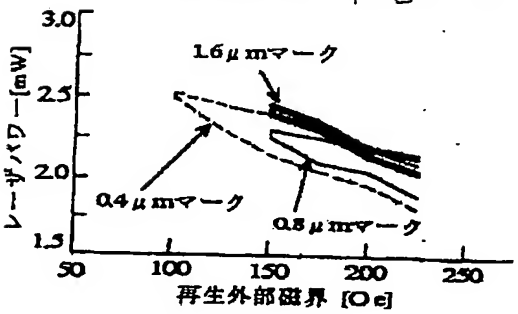


【図5】



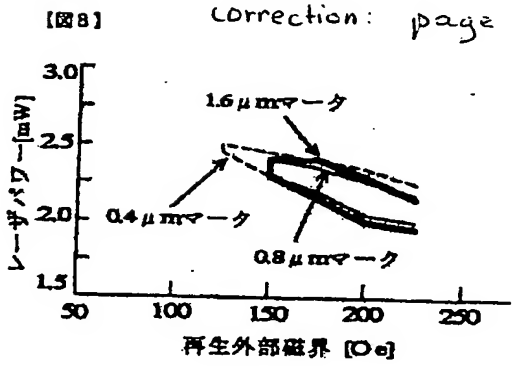
【図7】

correction: page 13

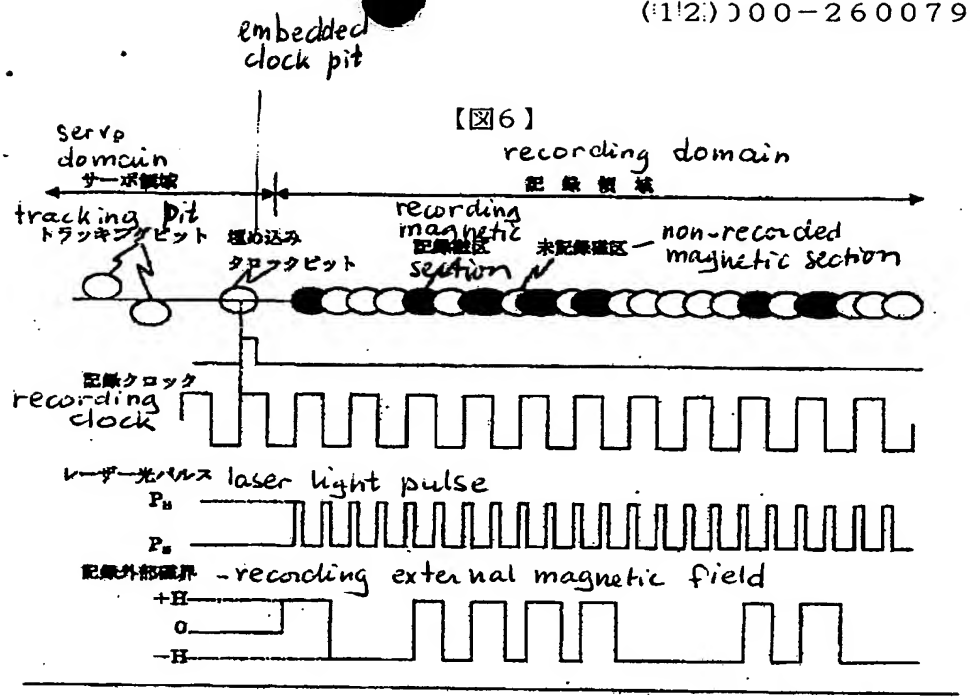


【図8】

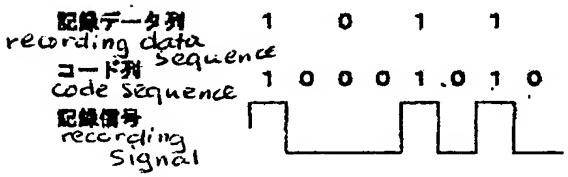
correction: page 13



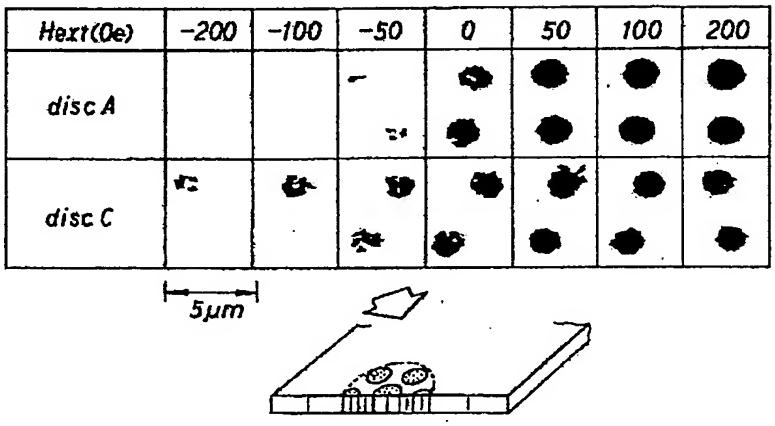
【図6】


embedded clock pit
servo domain
サーボ領域
recording domain
記録領域
tracking pit
トラッキングピット
埋め込みクロックピット
recording magnetic section
記録磁区
未記録磁区
non-recorded magnetic section
記録クロック
recording clock
レーザー光パルス
laser light pulse
P_H
P_L
記録外部磁界
recording external magnetic field
+H
0
-H

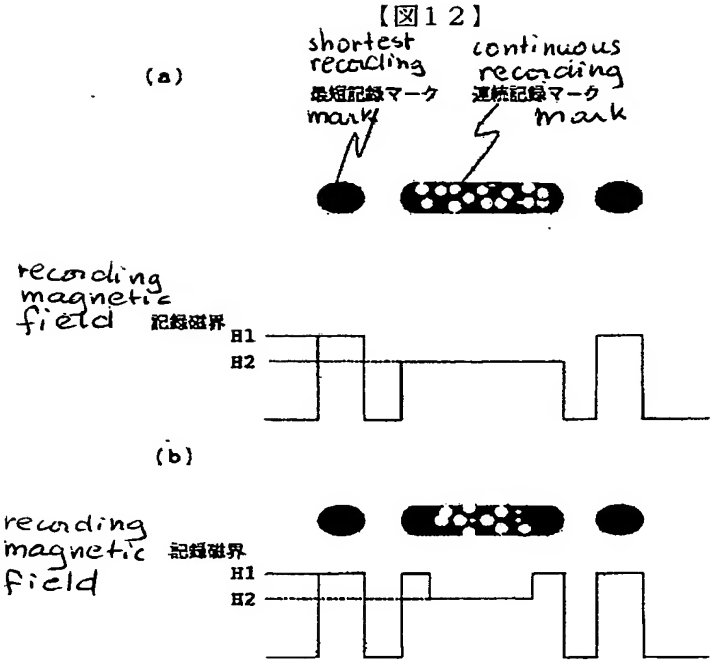
【図9】


記録データ列
recording data sequence
1 0 1 1
コード列
code sequence
1 0 0 0 1 0 1 0
記録信号
recording signal

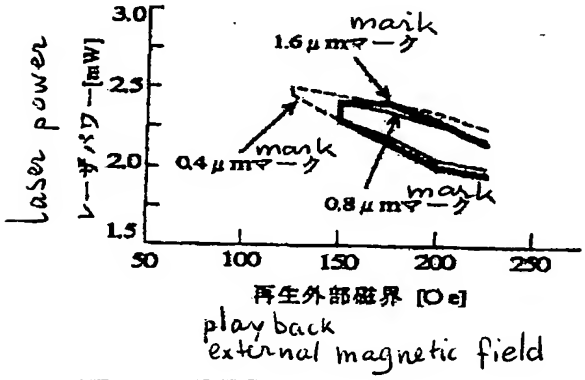
【図10】


Hext(Oe)
-200
-100
-50
0
50
100
200
disc A
disc C
5μm

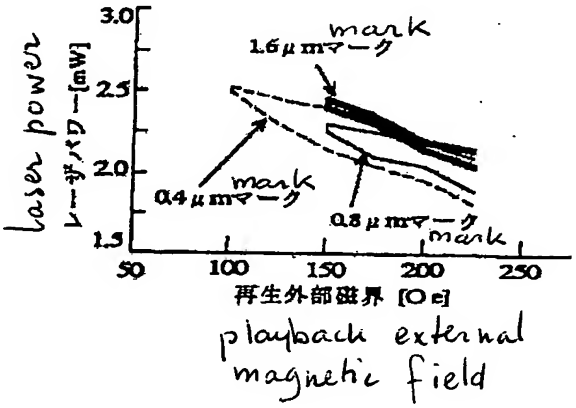
【図12】



【手続補正書】
【提出日】平成12年3月28日（2000．3．28）
【手続補正1】
【補正対象書類名】図面
【補正対象項目名】図7
【補正方法】変更
【補正内容】
【図7】



【手続補正2】
【補正対象書類名】図面
【補正対象項目名】図8
【補正方法】変更
【補正内容】
【図8】



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Fターム(参考)　5D075 CC01 CC04 CC11 DD01